Petrex Passive Soil Gas and Sediment Vapor Sampling System

NELP Fact Sheet No. 7 *Success Stories* **September 1996**

ABSTRACT

This is the seventh in a series of factsheets developed to provide information on technologies and strategies demonstrated at Naval Air Station (NAS) North Island under the Navy Environmental Leadership Program (NELP). This fact sheet provides information on the PETREX passive soil gas and sediment vapor sampling system demonstrated at NAS North Island. The PETREX sampling system was used to identify subsurface migration pathways and to determine whether dissolved phase contaminants are reaching San Diego Bay. The PETREX system is a remote sensing, near surface screening method that directly collects and identifies a large range of chlorinated, aliphatic, and aromatic contaminant vapors migrating to the surface from the soil and groundwater beneath each collection point. Soil gas is collected via free vapor diffusion of contaminants into the PETREX sampler; sediment vapor is collected in the sampler via the diffusion of dissolved phase contaminants through a water-tight gas permeable container. NAS North Island estimates that use of the PETREX system to characterize contaminant migration at Site 9 saved the Navy more than $100,000 in characterization costs. This fact sheet was written to encourage other Naval installations to consider this technology at their facilities.

BACKGROUND

On October 23, 1993, the Secretary of the Navy approved implementation of NELP at NAS North Island, California, and Naval Station Mayport, Florida. NELP was established to find new, improved, and more cost-effective ways to manage environmental programs at Naval facilities. NELP initiatives at NAS North Island focus on identifying and demonstrating innovative cleanup, compliance, pollution prevention (P2), and conservation technologies that reduce costs and will have broad application Navy-wide.

As a result of past waste and resource management practices at NAS North Island, some areas of the installation are contaminated with various hazardous substances. One of these areas, Site 9 (a former chemical waste disposal area) contains high concentrations of volatile organic compounds (VOC), semivolatile organic compounds (SVOC), and metals in the soil and groundwater. Groundwater samples collected from downgradient monitoring wells suggest that contaminants have migrated more than 1,000 feet

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west toward San Diego Bay. Furthermore, seepage meters located in the bay floor indicate that groundwater is discharging into the bay only 50 feet west of the shoreline at the site. Figure 1 shows the location of Site 9 and San Diego Bay. To determine the pathway and extent of contamination migration from Site 9 and evaluate the potential discharge of contaminants from the site into San Diego Bay, a soil gas and sediment vapor survey was conducted on-shore and offshore of Site 9 using the PETREX passive soil gas sampling system.

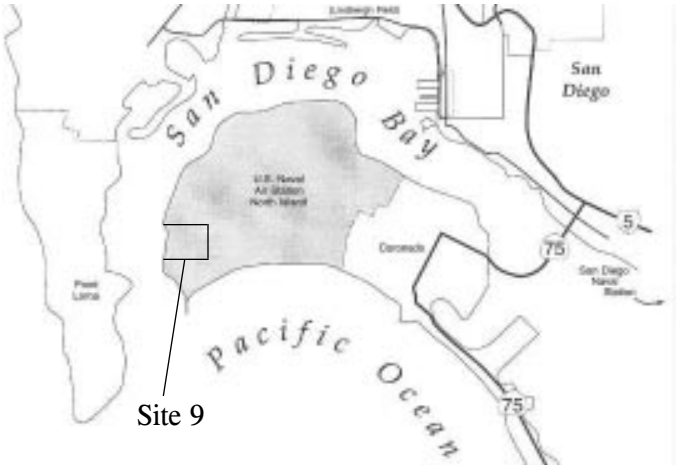

Figure 1 - Site Vicinity Map

TECHNOLOGY DESCRIPTION

The PETREX sampling system is an innovative soil gas sampling technology developed by Northeast Research Institute (NERI) Limited Liability Corporation (recently purchased by W.L. Gore and Assoicates). The passive soil gas method was originally developed at the Colorado School of Mines for petroleum exploration and has been widely used for mapping trace levels of hydrocarbons diffusing from natural sources. In recent years, the system has been adapted to the environmental field for characterization of a wide range of VOCs and SVOCs in terrestrial and shallow marine environments. A schematic diagram of a PETREX soil gas sampler is shown on Figure 2.

The sampling system uses patented sample collectors, known as PETREX tubes, to directly collect VOCs and SVOCs in the soil gas or sediment vapor emanating from subsurface sources. The PETREX tubes consist of two or three activated carbon adsorption elements fused to ferromagnetic wire collectors housed in an inert atmosphere in a resealable glass tube. Soil gas samples are collected by unsealing the sampler and exposing the collector to the soil gas of the subsurface environment at the base of a shallow bore hole. Sample collection proceeds via free vapor diffusion through the opening of the uncapped sampler container. For shallow marine applications, the PETREX samplers are placed in water-tight gas permeable containers, such as polyethylene bags, before they are placed in the sediment using a drive shoe. Figure 3 depicts a PETREX sampler installed in sediments.

After a controlled period of time to allow sufficient loading of gases onto the activated carbon adsorbent wires, the sampler is retrieved from the bore hole, resealed, and submitted for analysis at NERI's laboratory. Contaminants are thermally desorbed directly into a mass spectrometer (MS) for analysis. Because samples are collected over a period of time and are analyzed using a MS, results are reported in ion flux counts rather than concentrations. Flux counts are related to concentrations but cannot be extrapolated directly.

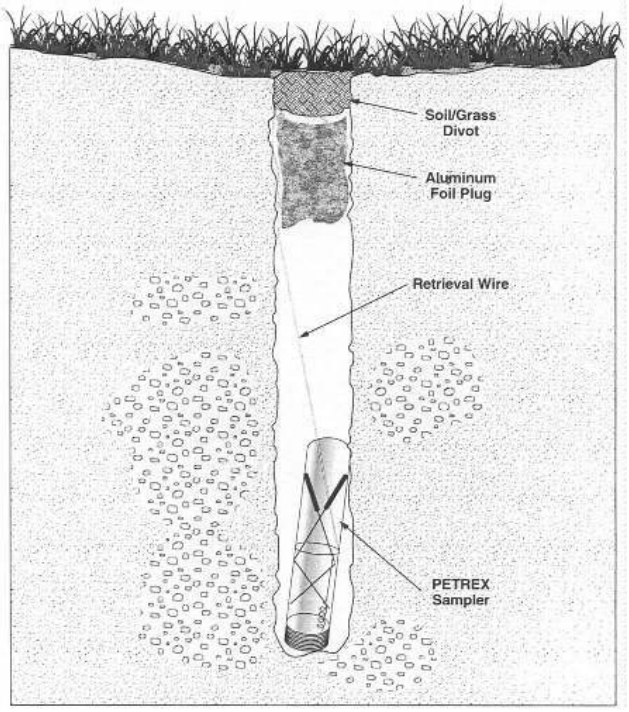

Figure 2 - PETREX Soil Gas Installation

OPERATIONAL SUPPORT REQUIREMENTS

Operational support requirements for conducting a soil gas survey using the PETREX passive sampling system

method are minimal and are limited to PETREX sample tubes, hand augers or other coring device to reach the appropriate sampling depth, field personnel trained in the use and installation of the sampling tubes, and laboratory services to analyze the samples. Offshore sediment vapor sampling may require trained divers to install and retrieve the PETREX samplers.

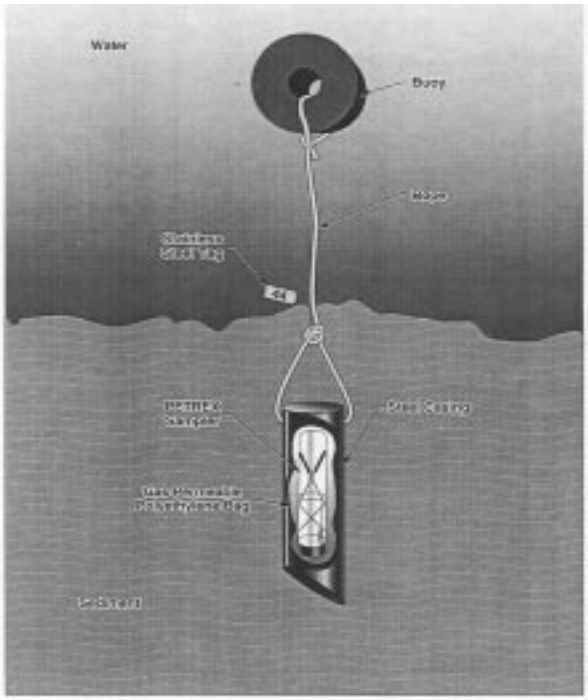

Figure 3 - PETREX Sediment Vapor Installation

All necessary equipment for conducting soil gas surveys using the PETREX passive sampling method is provided by NERI; NERI is the only supplier of PETREX sample tubes and associated laboratory services. NERI also provides mandatory training on the installation and use of the PETREX sampling tubes for clients who wish to conduct their own field work.

DEMONSTRATION RESULTS

To identify potential contaminant migration pathways and evaluate the potential discharge of contaminants into San Diego Bay, the demonstration at Site 9 was conducted in three phases: (1) presurvey field test, (2) on-shore survey, and (3) offshore survey. During Phase 1, a presurvey was conducted by suspending PETREX sample collectors in four groundwater monitoring wells containing a known range of contaminants and concentrations. The results of the presurvey field test showed a good order-of-magnitude agreement between both contaminant type and concentration in the monitoring wells and contaminant type and ion flux counts reported in the PETREX samplers. The presurvey results are summarized in Table 1. Based on these results, Phases 2 and 3 were implemented. The on-shore soil gas survey consisted of installing 30 PETREX samplers at 50-foot intervals in a rectangular grid measuring 30,000 square feet. The offshore sediment vapor survey involved installing 105 PETREX samplers at depths ranging from 10 feet to 60 feet below the water surface. The offshore sample points were installed by commercial divers at 50-foot intervals in a uniform rectangular grid measuring 200,000 square feet. The PETREX soil gas and sediment vapor samplers installed during Phase 2 and 3 were exposed in the field for approximately 3 weeks before they were retrieved and analyzed.

Results of the on-shore surveys indicated that two localized areas of tetrachloroethene and trichloroethene contamination were present, corresponding roughly to two suspected buried stream channels that may provide contaminant pathways from Site 9 to the San Diego Bay. Offshore survey results indicated that low concentrations of VOCs and petroleum hydrocarbons dissolved in groundwater are discharging into the bay. The results

TABLE 1 - PRESURVEY RESULTS

PETREX Sampler	TCE Ion Flux Count	Monitoring Well	TCE Concentrati (μg/L)	PCE Concentratio (μg/L)	Cis-1,2-DCE Concentratio (μg/L)
1	$3.2x10^6$	9-MW-20	22,316	ND	10,845
2	$4.6x10^6$	9-MW-16	15,890	48	5,422
3	$2.3x10^5$	9-MW-14	455	2	13
4	ND	9-MW-12	ND	ND	ND

TABLE 2 - PETREX and Verification Sample Results

Compound	Grid 40 PETREX Sample Results (Ion Flux Control)	Grid 40 Verification Sample Results (µg/L)	Grid 42 PETREX Sample Results (Ion Flux Control)	Grid 42 Verification Sample Results (µg/L)
DCE	943,418	18,450*	34,816	19,125*
TCE	829	51	ND	8

ND	Not Detected
µg/L	Microgram per Liter
TCE	Trichloroethene
PCE	Tetrachloroethene
DCE	Dichloroethene
*	Total DCE Concentration

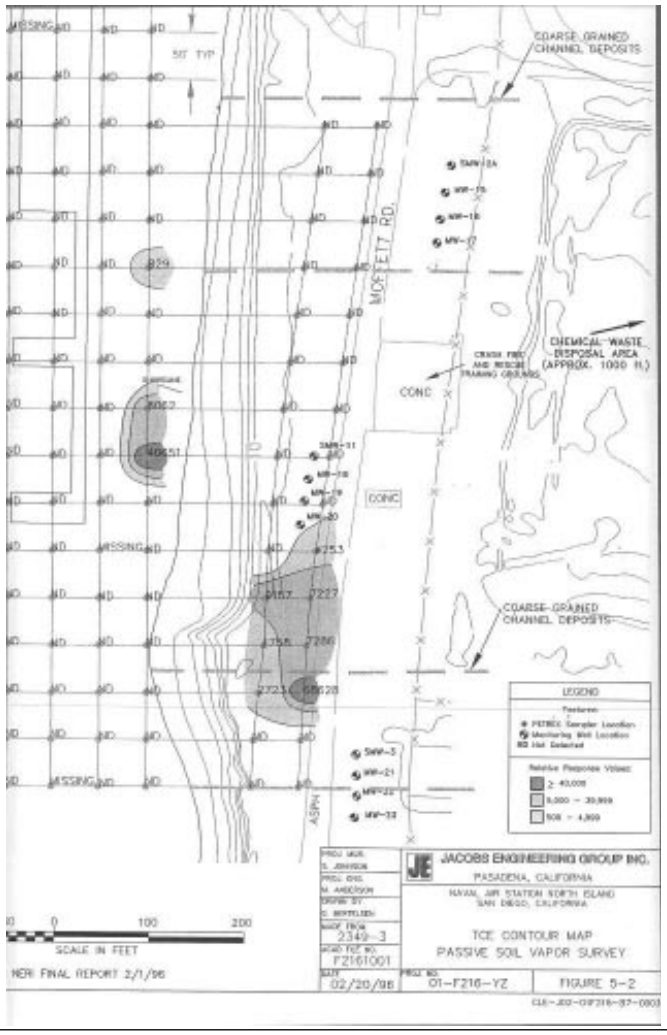

figure 4 - Interpreted Extent of Trichloroethene

also indicate that highly chlorinated, toxic hydrocarbons are being reduced to less chlorinated, less toxic forms as they migrate through the subsurface. In addition to defining migration pathways, the data also help to confirm the conceptual site model, which had predicted discharge of contaminated groundwater from Site 9 into the bay. Analytical results obtained from verification samples collected using a Vibracore sampler were consistent with the PETREX sample results. PETREX and verification sample results are presented in Table 2 and the interpreted extent of trichloroethene is depicted on Figure 4.

BENEFITS

The PETREX sampling system provides a fast and inexpensive means to identify VOCs and SVOCs in the soil gas and sediment vapor. The demonstration at Site 9 showed the following advantages of this system:

- The PETREX samplers can collect a broad range of VOCs and SVOCs at each sampling point. This ability makes the PETREX system a useful screening tool for identifying and mapping the relative abundance of a wide array of chemical compounds at VOC- and SVOC-contaminated sites.

- By acquiring a sample over an optimal period of time determined by site conditions, the PETREX samplers are significantly more sensitive than active methods using either portable or laboratory based instrumentation. Increased sensitivity allows the PETREX system to detect lower contaminants from sources at greater depths from the surface through tighter soil. Because the PETREX samplers continually collect soil gas over time, they also eliminate short-term variations associated with other soil gas detection methods.

- The PETREX samplers provide high-resolution site reconnaissance data regarding the presence of VOCs and SVOCs emitting from subsurface sources. These data can be used to direct subsequent investigations, reducing both the overall time and cost to complete site characterization.

- Passive soil gas and sediment vapor surveys using PETREX samplers causes minimal site disruption, can be installed using hand tools, generate minimal amount of investigation-derived waste, and require minimal mobilization and demobilization. These attributes allow the PETREX system to be implemented quickly at minimal cost.

- The PETREX sampling system can be used under water, allowing the evaluation of sediment vapor in shallow marine environments.

TECHNOLOGY LIMITATIONS

The PETREX passive soil gas and sediment vapor sampling system can be limited by the following factors:

- The ion count of a compound at one sampling location cannot be compared to that of another compound because of the chemical differences between individual compounds, including their ability to both adsorb and desorb from the charcoal PETREX collector elements. In addition, ion count cannot be directly correlated to groundwater or soil contaminant concentrations.

- As with other soil gas sampling methods, the effectiveness of the PETREX system for site screening and characterization will be influenced by irregularities in the near-surface and subsurface environment through which the soil gas diffuses. These irregularities include man made structures, such as concrete foundations, drainage systems, and wells, and such naturally occurring features as fractured and unfractured bedrock, clay, and shale lenses. Other factors influencing the soil gas signal include groundwater and surface water, the free carbon content of soil, microbiotic activity in the soil, and natural and synthetic ground cover.

COST

The cost to implement a 30,000-square-foot on-shore soil gas survey and a 200,000-square-foot offshore sediment vapor survey at NAS North Island was approximately $30,000. This cost included procurement of PETREX samples tubes, on-shore and offshore installation and retrieval of the samples, sample analysis, data interpretation, and reporting. NAS North Island estimates that the survey saved the Navy more than $100,000 in characterization costs compared to traditional sediment sampling techniques. Cost information obtained from NERI indicates that individual PETREX samplers range from $60 to $100 per sampler, depending on purchase volume. The cost for sample analysis is $175 per sample. NERI claims that the PETREX system can be used to screen sites before initiating expensive drilling programs, thereby reducing the number of borings required and substantially reducing overall site characterization costs.

SOURCES OF ADDITIONAL INFORMATION

Additional technical and implementation information can be obtained from:

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Southwest Division, Naval Facilities Engineering Command
2585 Callagan Highway
Naval Station San Diego
San Diego, California 92136-5198
Phone: (619) 556-9901
Fax: (619) 556-8929
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Mark Hatheway
W.L. Gore and Associates
959 Glastonbury Turnpike
Portland, Connecticut 06480
Phone: (860) 342-1037

Additional Information about the Navy Environmental Leadership Program can be obtained on the Internet WWW Site at:

http://nasni.navy.mil/~nelp/nelp.htm

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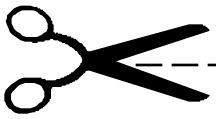

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